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RADIOCARBON DATING LEGACY COLLECTIONS: A BAYESIAN ANALYSIS OF HIGH-PRECISION AMS ¹⁴C DATES FROM THE PAR-TEE SITE, OREGON

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Abstract

Archaeological materials in museum collections provide an excellent opportunity for researchers to investigate social, cultural, and environmental change. However, the precision of the archaeological analysis and interpretation is dependent on a firm understanding of the site chronology. The Par-Tee site (35CLT20), located on the northern Oregon Coast, produced a large archaeological collection including artifacts and faunal remains excavated in the 1960s and 1970s. Radiocarbon dates have been obtained on materials from the Par-Tee collections by several different researchers since the 1970s, but these data have not been adequately assessed for chronometric hygiene. To establish a reliable chronology for the Par-Tee site, we obtained new high-resolution accelerator mass spectrometry (AMS) radiocarbon dates and collagen peptide mass fingerprinting of cervid bones from throughout the site. We evaluate these new radiocarbon dates along with previous radiocarbon dates from the site, using chronometric hygiene assessments and Bayesian statistics to build a refined chronology for the Par-Tee site and museum collection. Previous research suggests site habitation occurred between 350 cal BC to cal AD 1150. Our reassessment of the site chronology suggests the primary site habitation occurred from cal AD ~100-800. We also identified evidence of subsequent site occupation around cal AD ~1490-1635 supporting previous interpretations of site habitation after the primary shell midden forming occupation. The latter occupation may be associated with a change in site use from a semi-sedentary village to a cemetery.

Keywords

Pacific Northwest Coast, Museum-based Research, Oregon Archaeology, Collagen Peptide Mass Fingerprinting

1. Introduction

Museum-based archaeological research offers access to unique archaeological materials sometimes unobtainable through modern studies—a result of the often large-scale of late-nineteenth and early twentieth-century excavations. Although concerns of decreasing museum repository space are increasing (Bawaya 2007), anthropological research of museum collections is addressing a diverse range of anthropological, biological, and conservation issues (Sholts et al. 2016). Collections-based studies, however, can be complicated by the differential excavation, recovery, and curation histories of museum collections (Bawaya 2007; Pearce 1994). As Luby et al. (2013) note, these early museum assemblages endure as legacy collections rather than as “old” excavation materials. The term legacy highlights the inherent value and the importance of museum collections from the perspective of stewardship, research, and education.

Prior to initiating museum-based studies on legacy collections, conservation, rehousing, and basic inventorying of an assemblage may need to be completed—potentially deterring researchers from museum studies (Luby et al. 2013). Museum-based research also requires understanding museum-specific catalog systems, collections processing, and field sampling strategies, the availability of associated field notes and photographs, and deaccessioning practices (Huster 2013; Luby et al. 2013; Voss 2012). Despite these and other obstacles, analysis of archaeological museum collections is an important pursuit, where large collections can be analyzed on their own, or supplement new excavations at a site (Crowell 2000; Luby et al. 2013; Rick 2007).

One of the biggest issues when conducting museum-based research—and in archaeology more generally—is establishing the chronology of an assemblage or site (Buck et al. 1991; Finstad et al. 2013; Schweikhardt et al. 2011). Frequently, in legacy collections, older radiocarbon (^{14}C) measurements were made on composite or bulk samples of charcoal, shell, or bone. Often, samples were not corrected for isotopic fractionation, isotopic ratios were estimated rather than measured, or dates have high standard deviations that make them problematic for building chronologies (Ashmore 1999; Bronk Ramsey et al. 2004; Stuiver and Polach 1977; Taylor 1991). After proper chronometric hygiene assessments of existing ^{14}C dates, it is often desirable for archaeologists to obtain new AMS dates for sites, building potentially higher resolution chronological sequences of legacy collections (Kennett et al. 2014; Luby et al. 2013). Bayesian analysis of high-precision AMS ^{14}C dates provides an important framework for enhancing the interpretation of existing collections and increasing their broader value to the scientific community (Bronk Ramsey et al. 2004; Jew et al. 2015; Kennett et al. 2011; Thulman 2017).

In this paper, we present the results of recent, high-resolution AMS ^{14}C dating and Bayesian analysis for the Par-Tee site (35CLT20), which produced a large archaeological collection from the northern Oregon Coast. The Par-Tee assemblage includes ~7,000 artifacts, including bone and antler tools, as well as a massive collection of faunal materials from nearly 300 excavation units that make it one of the most intensively excavated sites along the Pacific Coast of the Americas (Colten 2002; 2015; Losey and Yang 2007; Phebus and Drucker 1979; Sanchez et al. 2016; Wellman et al. 2017). We selected thick and dense cortical bone fragments, presumably from cervids for ^{14}C dating due to their excellent preservation and widespread distribution throughout the site. Previous research suggests that elk (*Cervus* sp.) and deer (*Odocoileus* sp.) dominate the Par-Tee terrestrial mammal remains (Colten 2002; 2015) and represent the primary raw material in the bone and antler tool assemblage (Losey and Yang 2007; Sanchez et al. 2016). The cervid samples were also selected for dating because they are

non-diagnostic fragments whose destruction would not hinder future zooarchaeological analysis. We conducted collagen peptide mass fingerprinting, also known as Zooarchaeology by Mass Spectrometry (ZooMS), for each specimen to ensure that only cervids were included in the revised chronology, obviating uncertainties associated with local marine reservoir offsets. Our analysis integrates ¹⁴C dating and ZooMS to refine the Par-Tee site chronology and anchor subsistence, technological, and other analyses of the collection.

2. The Archaeology of the Northern Oregon Coast

The northern Oregon Coast is part of the Pacific Northwest Coast Culture Area, which encompasses the region from Cape Mendocino in Northern California to Yakutat Bay, Alaska (Drucker 1955; Goddard 1945). The section of the Oregon Coast near the mouth of the Columbia River and south along the Clatsop Plains is an area culturally associated with the Chinookan speaking Clatsop and the Salish speaking Tillamook (Jacobs 2003; Silverstein 1990). Late Holocene age occupations predominate the archaeology of the Clatsop Plains. The late Holocene residential pattern of the Lower Columbia and northern Oregon Coast is commonly associated with permanent to semi-permanent villages inhabited during a majority of the year and for extended periods of time (Aikens et al. 2011). These residences were likely supported by storage-based economies (Aikens et al. 2011; Ames 2003). Complex social institutions like those observed during and after European contact are considered one of the hallmarks of the late Holocene cultural manifestations of the region (Aikens et al. 2011; Ames 2003).

In Seaside, Oregon three sites have been the focus of archaeological research: Par-Tee, Palmrose (35CLT47), and Avenue Q (34CLT13). George Phebus of the Smithsonian Institution and avocational archaeologist Robert Drucker excavated the three sites from the mid-1960s to the late 1970s (Phebus and Drucker 1973; 1979). Subsequent excavations at Palmrose and Avenue Q were conducted by the Oregon State Museum of Anthropology, University of Oregon (Connolly 1992). Based on the previous research, Palmrose was occupied from about 2335-1745 cal BC to cal AD 50-535 (Connolly 1992), Avenue Q from 1925-1225 cal BC to cal AD 690-995 (Connolly 1992), and Par-Tee from 350 cal BC to cal AD 1150 (Losey and Yang 2007; Sanchez et al. 2016).

Palmrose is recognized to contain one of the earliest known large plank houses on the southern Northwest Coast, its estimated size being 12 x 6 m (Aikens et al. 2011; Ames and Maschner 1999; Connolly 1992). The plank house appears to have been built and rebuilt several times from 800 BC to AD 400 (Ames and Maschner 1999). The Palmrose site produced a diverse artifact and faunal assemblage that includes a number of zoomorphic and anthropomorphic carved bone and antler artifacts (Aikens et al. 2011; Connolly 1992). While faunal remains from the Palmrose collection excavated by Phebus and Drucker were formerly controlled by private individuals, it is currently curated at the Museum of Natural and Cultural History, University of Oregon.

Avenue Q appears to post-date the Palmrose occupation. No residential structures are known from the site, perhaps a result of the small-scale of the excavations and historic impacts related to city development. Analysis of mollusk shells from Palmrose and Avenue Q suggest that horse clam (*Tresus capax*), butter clam (*Saxidomus giganteus*), and littleneck clam (*Protothaca staminea*) were constituents of the shell middens (Connolly 1995). Connolly (1995) demonstrated that the mollusks indicate the former presence of an estuary nonexistent today due to the prograding coastline associated with the formation and growth of the Clatsop Plains.

3. Archaeological Investigations at Par-Tee

The Par-Tee site is located in the city of Seaside, south of the Columbia River mouth at the southern extent of the Clatsop Plains (Figure 1). Phebus and Drucker's excavations at Par-Tee included the excavation of at least 256 5×5 ft wide test units (~550 m²), dug in 1 ft arbitrary levels, with recovery of materials from excavated sediments screened over ¼ in sieves (Colten 2002; 2015; Losey and Power 2005; Losey and Yang 2007; Phebus and Drucker 1973; 1979).

Figure 1. Overview of the northern Oregon Coast, the location of the Par-Tee site, and a grid map of the site depicting ¹⁴C sampled excavation units.

Par-Tee is the largest Northwest Coast archaeological collection south of the Ozette site in Washington. Estimates suggest half of all artifacts collected during controlled excavations on the Oregon Coast originate from the Par-Tee site (Colten 2015; Losey and Power 2005; Lyman 1991). Despite the presence of the extensive collections, the Par-Tee site remains only partially reported (Lyman 1991; Phebus and Drucker 1973; 1979) with the majority of case-studies published in the last two decades and the vast majority of the collection never reported on

(Colten 2002; 2015; Losey and Power 2005; Losey and Yang 2007; Sanchez et al. 2016; Wellman et al. 2017). The Par-Tee assemblage has been housed at the Smithsonian's National Museum of Natural History since the 1970s and has been the subject of intensive Smithsonian collections care and preservation work that includes rehousing, decompressing, cataloging, and the identification of all faunal materials to general class (i.e., bird, fish, and mammal).

Previous studies differ in their interpretations regarding the duration, seasonality, and use of the Par-Tee site by indigenous people. At present, archaeologists interpret the Par-Tee site as a village that was occupied year-round (Arbolino et al. 2005). This interpretation is supported by vertebrate faunal analyses from the site that documented a variety of fishes, mammals, and birds, likely harvested during multiple seasons of the year (Colten 2002). Based on ethnographic and ethnohistorical accounts, Minor (1983) proposed that Seaside village sites, including Par-Tee, were inhabited during the fall salmon-fishing season as part of broader seasonal shifts in the indigenous settlement-subsistence patterns of the Northern Oregon Coast. According to the model, people alternated fishing grounds from the lower Columbia River, in the summer, to the Clatsop Plains in the fall. However, recent research supports the interpretation of Par-Tee as a semi-sedentary and year-round occupation (Arbolino et al. 2005; Colten 2002).

The Par-Tee artifact assemblage includes more than 7,000 artifacts, including projectile points and other flaked stone tools, 23 whale bone atlatls and atlatl fragments, antler digging stick handles and a diverse set of bone harpoon heads, composite toggling harpoons, and unilateral and bilateral barbed points (Losey 2010; Moss 2011). The assemblage also contains an assortment of awls and bone needles that possibly indicate the production of fishing nets, basket making, weaving, and sewing (Losey 2010; Moss 2011). The interpretation that woodworking occurred is supported by the presence of bone and antler handles for attaching adze blades in addition to the presence of used basalt spall choppers, elk antler wedges, and chisels and adzes produced from elk metapodials (Losey 2010; Moss 2011). The assemblage also holds a number of zoomorphic and anthropomorphic items as well as embellished artifacts such as incised bone and antler tools (Losey 2010; Moss 2011). Lastly, several pendant-like items from the site have carefully incised geometric designs and perforations including a perforated sturgeon (*Acipenser* sp.) opercle (Losey 2010).

According to Arbolino et al. (2005), following the primary shell midden forming occupation of Par-Tee, people utilized the site as a burial ground. The majority of burials at Par-Tee post-date the primary shell midden forming occupation based on previously reported ^{14}C and stratigraphic data. The human burials were shallow, flexed inhumations that were interred in the shell midden after site abandonment (Arbolino et al. 2005). Historic era artifacts support the presence of an even more recent occupation (post 1888). These include a bone handled pocket knife, square cut nails, Euro-American and Eurasian refined earthenware and porcelain ceramics, and other historic era artifacts. Ceramics produced by the George Jones' Stoke-on-Trent were manufactured around 1864-1873 and a J&G Meakin ceramic fragment was produced around 1888-1891 (Kowalsky and Kowalsky 1999). Therefore, the site appears to have three occupations, the primary shell midden, the later mortuary component, and a late 19th century historic era occupation.

3.1 Radiocarbon Dating: Previously Reported and Unreported Dates

Previous reports present 33 ^{14}C dates for the Par-Tee site. Conventional radiometric ^{14}C dating suggests that the occupation of Par-Tee occurred over a period of roughly 1500 years, between approximately 350 cal BC and cal AD 1150 (2300-800 cal BP) (Arbolino et al. 2005;

Colten 2002; Losey and Yang 2007; Sanchez et al. 2016). These dates derive from research spanning the last four decades. Significant advancements in ^{14}C dating warrant a reanalysis of the earliest dates reported.

Previous work by Smithsonian researchers reported 25 ^{14}C dates (Arbolino et al. 2005; Phebus and Drucker 1979). Six high-resolution AMS dates were published by Losey and Yang (2007) and two dates were obtained by Sanchez et al. (2016). The majority of ^{14}C samples submitted by Phebus and Drucker ($n=24$) were on large, composite charcoal samples. In the preparation of at least three charcoal samples (SI-653, SI-654, and SI-655) base pretreatment (e.g. NaOH, KOH washes) was not conducted, resulting in the potential inclusion of humates, affecting the reliability of the reported dates. In addition, of the 25 dates submitted by Phebus and Drucker, direct $\delta^{13}\text{C}$ measurements were made for only two charcoal samples. In the case of one sample of human remains, $\delta^{13}\text{C}$ was estimated rather than measured and the collagen yield was not reported. All but one of the uncalibrated ages falls between about 2055 ± 145 BP and 1000 ± 65 BP, with a single outlier (SI-588) at 3140 ± 100 BP (see Appendix 1). Five excavation units (SE10L, SW20G, NE12G, NE12F, and NE14G) had multiple ^{14}C dates and chronological reversals appear in all but one of these units (NE14G).

Six dates reported by Losey and Yang (2007) derive from one excavation unit (SE10L) and were AMS ^{14}C dates obtained on single marine shell samples taken from precise locations—2-inch horizontal bands of sediment. The marine shells correspond with charcoal samples dated by Phebus and Drucker and provide an additional evaluation of their dates. Six marine shell samples, two *Saxidomus giganteus* (butter clam) and four *Protothaca staminea* (Pacific littleneck clam) were submitted to Beta Analytic Inc. for AMS dating, with $\delta^{13}\text{C}$ measured on an isotope ratio mass spectrometer (IRMS). The conventional ages of these samples ranged only 200 ^{14}C years despite being derived from deposits spanning at least 62 inches (157.5 cm) of apparently well-stratified midden deposits (Table 1). Several samples from different depths produced identical dates and one chronological and stratigraphic reversal.

Table 1. AMS ^{14}C dates on marine shells from 35CLT20 reported by Losey and Yang (2007), with provenience, species identification, conventional age, $\delta^{13}\text{C}$, and calibrated age. Dates calibrated through the Marine13 calibration curve (Reimer et al. 2013) assuming a local marine reservoir effect (ΔR) of 240 ± 50 ^{14}C years after Erlandson and Moss (1999).

Lab #	Provenience: Unit/Level (depth in inches)	Material Dated	Conventional ^{14}C age	$\delta^{13}\text{C}$ (‰, VPDB)	Calendar Age Range (95.4% CI)
Beta-196687	SE10L, level 5, 52-54"	<i>Protothaca staminea</i>	1980 ± 40	-2.2	90 BC-AD 125
Beta-196688	SE10L, level 6, 66-68"	<i>Saxidomus giganteus</i>	1980 ± 40	-1.3	90 BC-AD 125
Beta-196689	SE10L, level 7, 70-72"	<i>Protothaca staminea</i>	2080 ± 40	-1.5	205 BC-AD 5
Beta-196690	SE10L, level 8, 84-86"	<i>Protothaca staminea</i>	2060 ± 40	-2.3	190 BC-AD 25
Beta-196691	SE10L, level 9, 98-100"	<i>Saxidomus giganteus</i>	2080 ± 40	-0.6	205 BC-AD 5
Beta-196692	SE10L, level 10, 116-118"	<i>Protothaca staminea</i>	2180 ± 40	-2.0	375 BC-AD 110

Sanchez et al. (2016) reported two AMS ^{14}C dates, one for a humpback whale phalanx and the other from an elk bone harpoon tip embedded in the whale bone. The whale bone and harpoon tip came from the southwest site area from unit 21F level 4. Calibrating the ^{14}C date from the elk bone suggests that opportunistic whaling potentially occurred on the northern Oregon Coast around cal AD 430-550 (see Losey and Yang 2007). The date from the humpback whale phalanx produced an age of 2120 ± 15 ^{14}C yr BP with estimated marine reservoir offsets between 210 ± 36 ^{14}C yr to 220 ± 37 ^{14}C yr, providing a date of cal AD 400–610 (Sanchez et al. 2016:401-402).

The 25 radiocarbon dates obtained by Phebus and Drucker present numerous interpretative challenges. First, as previously discussed, composite samples of wood are unreliable due to the combination of separate entities, resulting in the dating of multiple events rather than more discrete cultural activities (Ashmore 1999). Second, in Pacific Northwest rainforests, long-lived trees and drift logs were commonly a source of fuel, so dates of multiple unidentified charcoal fragments are likely significantly offset by in-built age and/or the ‘old wood’ effect (Dee and Bronk Ramsey 2014; Kennett et al. 2002; Sanchez et al. 2016; Schiffer 1986). Lastly, samples that lack stable carbon isotope measurements are prone to inaccuracies and it is unclear precisely how these were measured, raising questions about correcting these dates. Furthermore, several of these dates have large standard deviations (>100 years) that raise additional questions about their accuracy. For all these reasons, in re-examining the potential age range for Par-Tee site human occupation, we follow basic principles of chronometric hygiene (Fitzpatrick and Jew 2018; Hunt and Lipo 2006; Pettitt et al. 2003; Spriggs 1989; Wilmshurst et al. 2011), in excluding all dates previously reported by Phebus and Drucker (1973; 1979). In addition, we exclude previously reported ^{14}C dates from marine organisms (Losey and Yang 2007; Sanchez et al. 2016) to avoid uncertainties associated with corrections for regional marine reservoir effects.

4. Material and Methods

The Smithsonian Institution’s National Museum of Natural History houses all the Par-Tee collections and materials sampled in this study. To maintain standard sampling strategies, we rely on a new series of high-resolution ^{14}C dates for the current study and exclude previously reported AMS ^{14}C dates from marine organisms (Losey and Yang 2007; Sanchez et al. 2016). However, we include one previously reported ^{14}C date on elk bone reported by Sanchez et al. (2016). Fifteen bone samples from four excavation units (NE9F, NE16F, SW19D, and SE8G) from the Par-Tee assemblage were sampled for the analysis. Rick and Sanchez selected three bone samples per unit, except for SW19D where five samples were selected and NE9F with four samples. Individual samples derive from distinct arbitrary excavation levels. To minimize our impact on the collection, we selected non-diagnostic long bone fragments for the study that appeared to be Cervidae remains based on cortical bone thickness or metapodial groove presence. To our knowledge, none of the samples has ever been treated with any pesticides or other materials that may influence our results. Rick used sterile surgical blades to remove 0.5-1 g of bone material, removing two samples from each specimen. Subsamples were sent to the Human Paleoecology and Isotope Geochemistry Laboratory at Pennsylvania State University (PSU) for pretreatment and later the W.M. Keck Carbon Cycle AMS Laboratory, University of California-Irvine for AMS dating. In addition, the PSU AMS Facility analyzed two samples for AMS dating. The second sub-sample was sent to the Manchester Institute of Biotechnology, University of Manchester for ZooMS analysis.

4.1 ZooMS Methods

Advances in faunal identification methods through molecular fingerprinting provide researchers the opportunity to limit research impacts on museum archaeological collections (Buckley et al. 2008; 2014; Collins et al. 2010; Richter et al. 2011) while maximizing data gathering potential. Collagen peptide mass fingerprinting (i.e., ZooMS) facilitates the use of highly fragmented faunal remains in research, allowing for the molecular barcoding of archaeological samples—even those in which ancient DNA (aDNA) is no longer readily retrieved—to family, genus, and in some cases, species level identification (Rybczynski et al. 2013; Speller et al. 2016). Collagen is the most abundant protein in bone and preserves for millions of years in some environments (Rybczynski et al. 2013). Thus, collagen peptide mass fingerprinting allows researchers to identify highly fragmented faunal remains to better understand animals present in an assemblage, human processing, and non-cultural taphonomic factors affecting the representation of species (Buckley et al. 2017).

ZooMS collagen fingerprinting was carried out following van der Sluis et al. (2014). Bone powder was demineralized with 0.6 M HCl overnight and ultrafiltered into ammonium bicarbonate (50 mM) using 10 kDa molecular weight cut-off filters (Vivaspin, UK). The retentate was then digested with 0.4 µg sequencing grade trypsin (Promega, UK) overnight at 37°C. Subsequently the digests were acidified to 0.1% trifluoroacetic acid (TFA) and the peptides purified and fractionated into 10% and 50% acetonitrile in 0.1% TFA fractions using C18 ZipTips (OMIX, UK) following Buckley et al. (2009). After centrifugal evaporation and resuspension in 10 µL 0.1% TFA, 1 µL samples were spotted with an equal amount of α -cyano hydroxycinnamic acid matrix onto a Bruker stainless steel Matrix Assisted Laser Desorption Ionization (MALDI) target plate and allowed to air dry. The fingerprints were then acquired using a Bruker Ultraflex II MALDI mass spectrometer with up to 2,000 laser acquisitions over the mass/charge (m/z) range of 700–3700. Spectra were compared with those of previous publications (e.g., Buckley & Kansa 2011; Buckley et al. 2010; 2017) for identification by matching selected peptide markers.

4.2 AMS Methods

At PSU, bone collagen was extracted and purified using the modified Longin method with ultrafiltration (Brown et al. 1988; Hoggarth et al. 2014). Samples (200–400 mg) were demineralized for 24–36 hr in 0.5N HCl at 5°C, followed by a brief (<1 hr) alkali bath in 0.1N NaOH at room temperature to remove humates. The pseudomorph was rinsed to neutrality in multiple changes of 18.2 MΩ H₂O, and then gelatinized for 10 hr at 60°C in 0.01N HCl. Gelatin solution was pipetted into precleaned Centriprep® 30 ultrafilters (retaining >30 kDa molecular weight gelatin) and centrifuged three times for 20 min, diluted with 18.2 MΩ H₂O and centrifuged three more times for 20 min to desalt the solution. More detailed ultrafilter cleaning methods are described in (McClure et al. 2010). Ultrafiltered collagen was lyophilized and weighed to determine percent yield as a first evaluation of the degree of bone collagen preservation. Carbon and nitrogen concentrations and stable isotope ratios were measured at the PSU Light Isotope Laboratory with a Costech EA (ECS 4010), Thermo Finnigan Conflo IV gas handling device, and a Thermo Finnigan Delta V analyzer. Sample quality was evaluated by % crude gelatin yield, %C, %N, and C:N ratios before AMS ¹⁴C dating. C:N ratios for the samples were around 3.43 to 3.26, indicating good collagen preservation (DeNiro 1985; van Klinken 1999). ¹⁴C samples (~2.5mg) were combusted for 3 hr at 900°C in vacuum-sealed quartz tubes

with CuO wire and Ag wire. Sample CO₂ was sent to W.M. Keck Carbon Cycle AMS facility at the University of California-Irvine (UCIAMS) or the PSU AMS Facility (PSUAMS), where it was reduced to graphite at 550°C using H₂ and a Fe catalyst, with reaction water drawn off with Mg(ClO₄)₂ (Santos et al. 2004) (Table 6). Graphite samples were pressed into targets in Al cathodes and loaded on the target wheel for AMS analysis. ¹⁴C ages were corrected for mass-dependent fractionation with measured δ¹³C values on the AMS (Stuiver and Polach 1977) and compared with samples of Pleistocene whale bone (background, >50 ka BP), late Holocene bison bone (~1850 ¹⁴C BP), late AD 1800s cow bone, and OXII oxalic acid standards.

4.3 Bayesian Statistical Modeling

Bayesian approaches to constructing archaeological chronologies incorporate prior information regarding the archaeological site(s) and regional culture histories in the formulation of models (Bayliss and Ramsey 2004; Bayliss et al. 2007; Kennett et al. 2011). Thus, new data are analyzed in a framework within the context of prior knowledge (Bayliss et al. 2007). For our analysis, ¹⁴C dates were calibrated using the IntCal13 calibration curve (Reimer et al. 2013) and models developed in OxCal 4.3 (Bronk Ramsey 1995). Bayesian analysis in OxCal allows researchers to situate dated events into models defining a sequence, a phase(s), and statistically calculate *terminus ante quem* and *terminus post quem* dates and their span when considering the chronology of a site or of specific events (Bayliss et al. 2007; Bronk Ramsey 1995; Hamilton and Krus 2018). Two statistics calculated in OxCal aid in the assessment of the reliability of a model: indices of agreement and convergence. For each dated sample in the models generated by OxCal, an agreement index is calculated. An overall agreement index for the model itself is also determined calculated from the individual agreement indices (Bayliss et al. 2007). As Bronk Ramsey (1995) notes, model agreement indices should not fall below 60%. If the index of agreement falls below 60% (analogous to 0.05 significance level in a X² test), the ¹⁴C results or the model is problematic (Bayliss et al. 2007). Therefore, agreement indices allow researchers to test for unreliable models or dates (Bayliss et al. 2007; Bronk Ramsey 1995).

Kennett et al. (2011) suggest five considerations in model building. These include precise stratigraphic excavation and selection of ¹⁴C samples, selection of short-lived organisms for dating, proper protocols of sample processing, understanding the taphonomic processes affecting sites and samples, and application of the appropriate model type and settings. A limitation of working with museum collections, especially those resulting from coarse-grained excavation methods compared to modern excavation practices, is that precise stratigraphic relationships may not be known or recorded and taphonomic processes affecting the site unspecified. However, OxCal provides a means to construct models to test *a priori* knowledge of the site and refine pre-existing concepts.

Bayesian analysis provides an opportunity to create a revised chronology for the Par-Tee site and more reliable estimates for the duration of occupation. In creating models for the site, we assumed that all deposits were in undisturbed stratigraphic order. To test this assumption and the stratigraphic integrity of the site and ¹⁴C samples we first created simple calibration models for individual excavation units during the first iteration of dating. ¹⁴C dates were placed in a sequence in OxCal with boundary start and end dates calculated.

5. Results

5.1 ZooMS Analysis

ZooMS analysis confirmed that all but one of the 15 bone samples selected were from cervids due to the presence of peptide markers at m/z 1196.6, m/z 1427.7, m/z 1550.8, m/z 2131.1, m/z 2883.4 and m/z 3033 (Figure 2). The one specimen found to derive from a non-cervid yielded markers not matching known collagen fingerprint for reference taxa. The non-cervid sample is derived NE9F-3 and measured $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values indicate isotope values consistent with marine organisms, in this case a marine mammal (see below). ZooMS analysis confirmed that our fragmentary bone samples were terrestrial in origin, supporting the use of the IntCal curve, with one exception.

Figure 2. MALDI-ToF mass spectrum of a collagen tryptic digest from sample NE16f-6, with markers collectively matching those for cervine deer at m/z 1196.6, 1427.7, 1550.8 (inset A), 2131.1, 2883.4 and 3033.4 (inset B).

5.2 Chronology Building First Iteration: Calibration

NE16F

The materials from excavation unit NE16F include three samples from levels 8, 6, and 5 (Figure 3). The conventional age for the specimens range from 1735 ± 20 BP to 1535 ± 15 BP, with isotopic values typical of a terrestrial herbivore (Table 2). The agreement indices for the model are $A_{\text{model}}=73.3$ and $A_{\text{overall}}=73.7$ within the tolerance suggested by Bronk Ramsey (1995). No significant stratigraphic reversals are noted in the unit.

Figure 3. 35CLT20 Unit NE16F South Wall profile. Level provenience of ^{14}C samples noted. Adapted from Par-Tee excavation notes.

Table 2. AMS ^{14}C dates on cervid bones from first round of modeling for NE16F. Context designations derived from Phebus and Drucker excavation field notes.

Sample ID	PSU/UCIAMS #	$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{15}\text{N}$ (‰, Atm N_2)	Context	Conventional ^{14}C Age BP	cal AD (95.4% CI)	Modeled cal AD (95.4% CI)
PT12	7052/174931	-23.7	5.1	Level 8- Crushed shell and rock matrix	1735 ± 20	240-380	250-385
PT11	7051/174930	-25.9	4.3	Level 6- Mixed mussel shell and clam shell matrix	1535 ± 15	430-575	425-490
PT10	7050/174929	-25.5	4.0	Level 5- Clam shell matrix	1570 ± 15	425-540	440-540

NE9F

Four samples from excavation unit NE9F were dated, from levels 8 (n=1), 5 (n=1), and 3 (n=2) (Figure 4). For this unit, we exclude one date from level 3 that was derived from marine mammal bone due to issues with the marine reservoir effect and unknown taxonomic designation potentially biasing calibration.

The conventional ages for the unit span from 1660 ± 15 BP to 330 ± 15 BP, with isotopic values typical of a terrestrial herbivore (Table 3). The excluded marine mammal sample conventional age is NE9F-3 2015 $\pm$ 25 BP (PSUAMS-1345: $\delta^{13}\text{C}$: -12.3 VPDB; $\delta^{15}\text{N}$: 14.7‰ Atm N₂). The agreement indices for the model are $A_{\text{model}}=97.9$ with an $A_{\text{overall}}=97.9$ well within the tolerance suggested by Bronk Ramsey (1995).

Figure 4. 35CLT20 Unit NE9F South Wall profile. Level provenience of radiocarbon samples noted. Adapted from Par-Tee excavation notes.

Table 3. AMS ^{14}C dates for cervid bone samples from first round of modeling for NE9F. Context designations derived from Phebus and Drucker excavation field notes.

Sample ID	PSU/UCIA MS #	$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{15}\text{N}$ (‰, Atm N ₂)	Context	Conventional ^{14}C Age BP	cal AD (95.4 % CI)	Modeled cal AD (95.4% CI)
PT09	7049/174928	-25.3	4.1	Level 8-	1660 ± 15	340-	340-420

				Subsoil rock and gravel		420	
PT08	7048/174927	-25.6	2.7	Level 5- Mussel shell, clam, and humus mixed	1515 ± 15	435- 605	470-605
PT07	7047/174926	-22.4	7.0	Level 3- Humus/c lam shell and disturbe d surface	330 ± 15	1490- 1640	1485- 1640

SE8G

The materials from excavation unit SE8G include three samples from excavation levels 7, 5, and 3 (Figure 5). The conventional ages for the samples range from 1770 ± 15 BP to 1440 ± 15 BP, with isotopic values typical of a terrestrial herbivore (Table 4). The agreement indices for the model are A=0 outside the tolerance suggested by Bronk Ramsey (1995) due to the stratigraphic reversal present in level 5.

Figure 5. 35CLT20 Unit SE8G West Wall profile. Level provenience of radiocarbon samples noted. Adapted from Par-Tee excavation notes.

West Wall, Unit #SE8G 35CT20 Par-Tee

Table 4. AMS ^{14}C dates for cervid bones from first round of modeling for Unit SE8G. Context designations derived from Phebus and Drucker excavation field notes.

Sample ID	PSU/UCIAMS #	$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{15}\text{N}$ (‰, Atm N_2)	Context	Conventional ^{14}C Age BP	cal AD (95.4% CI)	Modeled cal AD (95.4% CI)
PT03	7043/174922	-25.1	4.0	Level 7- Mixed clam shell, mussel shell, and humus matrix	1590 ± 15	415-540	Not included
PT02	7042/174921	-21.5	5.4	Level 5- Clam and mussel shell matrix	1770 ± 15	225-335	Not included
PT01	7041/174920	-23.6	3.8	Level 3- Clam shell and overlying humus	1440 ± 15	590-650	Not included

SW19D

The materials from excavation unit SW19D include five samples from levels 7, 6, 5, 4 and 2 (Figure 6). The conventional ages for the samples range from 1640 ± 15 BP to 1300 ± 15 BP, with all isotopic values typical of a terrestrial herbivore (Table 5). The agreement indices for the model are $A_{\text{model}}=43.8$ with an $A_{\text{overall}}=48.4$ outside the tolerance suggested by Bronk Ramsey (1995) due to the stratigraphic reversal present in level 6.

Figure 6. 35CLT20 Unit SW19D South Wall profile. Level provenience of radiocarbon samples noted. Adapted from Par-Tee excavation notes.

South Wall, Unit #SW19D 35CT20 Par-Tee

Table 5. AMS 14C dates for cervid bones from first round of modeling for SW19D. Context designations derived from Phebus and Drucker excavation field notes.

Sample ID	PSU/UCIAMS #	$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{15}\text{N}$ (‰, Atm N ₂)	Context	Conventional ¹⁴ C Age BP	cal AD (95.4% CI)	Modeled cal AD (95.4% CI)
PT06	7046/174925	-25.7	4.9	Level 7- Sub-soil and rock/mixed humus, clam shell, and ash matrix	1640 ± 15	350-430	Not included
PT15	PSUAMS-1752	-21.9	2.9	Level 6- Mixed clam shell, humus ash matrix	1515 ± 20	430-605	Not included
PT14	PSUAMS-1751	-25.7	3.8	Level 5- Clam shell	1570 ± 20	425-545	Not included

				and humus matrix/clam shell and charcoal lens			
PT05	7045/174924	-26.2	4.2	Level 4- Clam shell matrix	1300 ± 15	665- 770	Not included
PT04	7044/174923	-25.6	3.6	Level 2- Shell/humus matrix	1315 ± 20	655- 770	Not included

5.3 Second Iteration: Models, Phases and Duration of Occupation

As the calibrations of dates from the four units demonstrate, stratigraphic reversals are found in the southern portions of the site in units SW19D and SE8G while the northern portion of the site seems to be stratigraphically intact. These findings may be supported by site observations recorded by Phebus and Drucker in 1970. On July 9th, field notes indicate that the:

“Upper strata of the SE quadrant of this site feature appreciable quantities of fire-cracked stone amidst the usual shell deposit. This [southern] area also features numerous indications of habitation such as hearths, lens[es], and structures. The absence of such traits in the midden of the NW quadrant seems to imply that that area was more properly site dump debris. This observation is consistent since the south side of the site would be the lee side and considerably more protected from the wind and weather. This condition may also exist on the Palmrose [35CLT47] site where dominant features occur primarily on the south side.”

If the primary site habitation zone was in the southern portion of the site with refuse being discarded to the north, this may explain why deposits to the north appear more homogenous than sediments to the south. Otherwise, the ¹⁴C reversals could be explained as a result of deposit mixing during site occupation, bioturbation, cross-cutting of discrete stratigraphic components—due to the excavation method of one foot arbitrary levels—or other natural or cultural factors (Ames 1996; Erlandson and Rockwell 1987; Jew et al. 2015; Losey 2005).

Following the first iteration of the Par-Tee calibration, we constructed a model of the site chronology based on evidence of site occupation from the ¹⁴C dates without emphasizing site stratigraphy, a result of the stratigraphic reversals (Table 6 and Figure 7). Given the coarse excavation methods at the site, the presence of stratigraphic reversals, and the limited excavation notes, we determined that defining the duration of occupation and identifying discrete phases of site occupation was best explored through an analysis and calibration of AMS ¹⁴C dates without reference to site stratigraphy.

We began by compiling all dates derived from the current analysis, the cervid remains, and a previously reported elk bone harpoon date (UCIAMS-137938) in chronological order in OxCal 4.3. The results appear to demonstrate a consistent occupation and cervid exploitation from cal AD 225 to cal AD 770. However, seven of the fourteen dates cluster around cal AD 415

to cal AD 605, suggesting the possibility for intensive site use around this time with more discrete and intermittent periods of occupation.

Table 6. Heuristic Analysis of AMS ^{14}C dates from the Par-Tee site.

Lab Number	Unmodelled cal AD (95.4% CI)
UCIAMS-174924	665-770
UCIAMS-174923	655-770
UCIAMS-174920	590-650
UCIAMS-174927	435-605
PSUAMS-1752	430-605
UCIAMS-174930	430-575
UCIAMS-137938	425-555
PSUAMS-1751	425-545
UCIAMS-174929	425-540
UCIAMS-174922	415-540
UCIAMS-174925	350-430
UCIAMS-174928	340-420
UCIAMS-174931	240-380
UCIAMS-174921	225-335

Figure 7. Calibrated AMS ^{14}C dates for the Par-Tee site ordered chronologically.

Model 1: Phases

Based on the data from the heuristic model we explored the possibility that there were discrete phases of cultural activity at the Par-Tee site, related to cervid exploitation and site use (Figure 7). The model estimates the depositional start and end dates for each phase. For the sequence we included start and end boundaries for the radiocarbon dates. Additionally, we included boundaries and phases around clusters of dates defined in the heuristic calibration, assuming these clusters of dates were a result of discrete or episodic site habitation or cervid exploitation (Table 7 and Figure 8).

The agreement indices for Model 1 are $A_{\text{model}}=112.5$ and $A_{\text{overall}}=109.6$.

Table 7. Model 1 Results

Model Description	Unmodelled cal AD (95.4% CI)	Modelled cal AD (95.4% CI)
Difference Span		350 to 630 cal yr
Boundary End		665-820
<i>UCIAMS-174924</i>	665-770	665-765
<i>UCIAMS-174923</i>	655-770	655-765
Phase e		
Boundary		600-750
<i>UCIAMS-174920</i>	590-650	590-650
Phase d		
Boundary		475-640
<i>UCIAMS-174927</i>	435-605	435-595
<i>PSUAMS-1752</i>	435-605	430-595
<i>UCIAMS-174930</i>	430-575	430-575
<i>UCIAMS-137938</i>	425-555	430-555
<i>PSUAMS-1751</i>	425-545	425-545
<i>UCIAMS-174929</i>	425-540	430-545
<i>UCIAMS-174922</i>	415-540	420-540
Phase c		
Boundary		395-520
<i>UCIAMS-174925</i>	350-430	380-425
<i>UCIAMS-174928</i>	340-420	345-420
Phase b		
Boundary		285-410
<i>UCIAMS-174931</i>	240-380	245-360
<i>UCIAMS-174921</i>	225-335	235-335
Phase a		
Boundary Start		140-335
Sequence		

Figure 8. Model 1 results.

Model 2: Phases

Following the calculation of Model 1, we further explored the potential for episodic deposition of cervid remains at Par-Tee. Model 2 includes the previous assumptions that date clusters result from cultural exploitation of cervids and site use. However, we include an

additional boundary separating each individual phase with discrete start and ends (Table 8 and Figure 9). The boundaries would suggest more episodic site use with periods of no habitation.

The agreement indices for Model 2 are $A_{\text{model}}=117.3$ and $A_{\text{overall}}=110.5$.

Table 8. Model 2 results.

Model Description	Unmodelled cal AD (95.4% CI)	Modelled cal AD (95.4% CI)
Difference Span		375 to 750 cal yr
Boundary End		670-895
Boundary End e		665-780
<i>UCIAMS-174924</i>	665-770	660-765
<i>UCIAMS-174923</i>	655-770	660-765
Phase e		
Boundary Start e		625-760
Boundary End d		595-685
<i>UCIAMS-174920</i>	590-650	590-650
Phase d		
Boundary Start d		540-645
Boundary End c		440-610
<i>UCIAMS-174927</i>	435-605	435-580
<i>PSUAMS-1752</i>	430-605	435-580
<i>UCIAMS-174930</i>	430-575	430-570
<i>UCIAMS-137938</i>	425-555	435-560
<i>PSUAMS-1751</i>	425-540	435-550
<i>UCIAMS-174929</i>	425-540	435-545
<i>UCIAMS-174922</i>	415-540	440-545
Boundary Start c		415-535
Boundary End b		385-480
<i>UCIAMS-174925</i>	350-430	380-425
<i>UCIAMS-174928</i>	340-420	360-425
Phase b		
Boundary Start b		320-415
Boundary End a		255-385
<i>UCIAMS-174931</i>	240-380	245-345
<i>UCIAMS-174921</i>	225-335	240-335
Phase a		
Boundary Start a		205-335
Boundary Start		80-325
Sequence		

Figure 9. Model 2 results.

6. Discussion

The Bayesian analysis and calibration of the latest AMS ^{14}C dates of the Par-Tee site suggest the site was occupied between cal AD ~200 and cal AD 800 based on the unmodeled radiocarbon calibrations. The Bayesian models that explored the potential for discrete or episodic use of the site, suggest that although the Par-Tee site likely witnessed an intense occupation period at cal AD ~400-650, the site was occupied at a maximum from cal ~AD 100-900, as evidenced in models 1 and 2. These new data constrain the overall occupation of the Par-Tee

site, which was previously believed to have dated from 350 cal BC to cal AD 1150 a span of 1,500 years (Arbolino et al. 2005; Colten 2002; Losey and Yang 2007; Sanchez et al. 2016). The new high-precision AMS ^{14}C dates restrict the occupation of the site by more than half, from a period of ~1,500 years to ~700 years. This more restricted date range is consistent with two AMS ^{14}C dates obtained by Sanchez et al. (2016), one for a whale phalanx and a second for a cervid bone harpoon tip embedded in it. AMS dates on marine shells may expand the age range by a century or two closer to ~100 BC (Losey and Yang 2007), but uncertainties about spatial and temporal fluctuations in the regional marine reservoir effect make us less confident in those calibrated ages.

Our reanalysis of the Par-Tee chronology supports previous interpretations of a later site use, which we date to cal AD ~1490-1635, potentially contemporaneous with the use of the shell midden as a cemetery site (Arbolino et al. 2005). Further research of the Par-Tee assemblage is required to understand this later occupation. If ethnographic and ethnohistoric patterns of burying the dead in locations away from primary residences are consistent with the burial practices at Par-Tee, people may have used the site to bury their dead away from residential areas (Arbolino et al. 2005).

The revised chronology of the Par-Tee site suggests that our general understanding of the habitation of the broader Seaside region remains constant. At this time, Palmrose appears to be the most ancient of the three sites, followed by Avenue Q, and lastly Par-Tee. However, as the radiocarbon dates for Palmrose and Avenue Q are derived from unidentified charcoal samples with a high range of uncertainty ($\geq \pm 60$), refined dating efforts may change the chronology of human occupation at these sites, as well.

Our study minimizes one barrier to conducting research with the Par-Tee assemblage through the establishment of a more reliable chronology. The new ^{14}C dates for the Par-Tee site provide a well-defined and more constrained chronology for the analysis of the large artifact and faunal assemblage. The revised chronology enhances forthcoming and future research of the Par-Tee collection by allowing the cultural practices, material culture, and environmental data in the collection to be placed on a reliable chronological foundation.

7. Conclusion

Our ^{14}C dating of the Par-Tee museum specimens suggests that archaeologists should interpret historically reported ^{14}C dates with caution, especially those derived from composite samples of charcoal, bone, and shell and unidentified charcoal samples. In addition, our findings highlight the value of reanalyzing legacy collections with improved dating techniques. Although there appears to be more intensive use of the Par-Tee site between cal AD ~400-650, the majority of the Par-Tee site collection is best viewed as the result of a single long-term ~700-800 year occupation.

We recommend that researchers working with legacy collections assess previously reported ^{14}C dates for an assemblage for chronometric hygiene. In those instances where previous ^{14}C dates are lacking, fieldnotes and maps are incomplete, or available resources limit the number of ^{14}C samples obtainable, researchers can use Bayesian chronological modeling software to estimate the quantity of dates needed and to produce precise and accurate models where stratigraphic information is missing or coarse-grained excavation methods prevent the use of essential stratigraphic information (Hamilton and Krus 2018). As AMS dates continue to become less costly, the type of chronological work we conducted at Par-Tee is becoming increasingly accessible to researchers at other museums and repositories around the world.

In conclusion, the revised chronology of the Par-Tee site and the recent collections improvement work of the archaeological assemblage at the Smithsonian Institution will lead to further research of the large and diverse Par-Tee assemblage. Ultimately, our work reinforces studies that demonstrate the value of revisiting and building new chronologies in a Bayesian framework for important legacy collections housed in museums around the world (Jew et al. 2015; Kennett et al. 2011; Kennett et al. 2014; Thulman 2017). In addition, the integration of collagen fingerprinting and high-resolution AMS dating allows for precision in dating and calibration that can enhance the value of museum collections for topics of broad interest to archaeologists and other researchers, while minimizing impacts of research on museum collections.

Appendix 1. Summary of ^{14}C reported by Phebus and Drucker.

Lab #	Year submitted	Provenience	Stratigraphic context	Material dated	Measured ^{14}C age	Notes
SI-1565	1973	SE10L, level 5, 52-54"	Associated with bone chisel fragment; clam shell layer	Charcoal, fine shell	1035 $\pm$ 65	
SI-1566	1973	SE10L, level 6, 66-68"	Associated with blade fragment and adze handle; humus, ash layer	Charcoal, fine shell	1090 $\pm$ 65	Sample appears to crosscut two strata.
SI-1567	1973	SE10L, level 8, 84-86"	Mussel shell, clam shell layer	Charcoal, fine shell	1540 $\pm$ 105	
SI-1568	1973	SE10L, level 9, 98-100"	Associated with chisel fragment; clam shell layer	Charcoal, fine shell	1645 $\pm$ 65	
SI-1569	1973	SE10L, level 10, 108-110"	Associated with chisel fragment; ash, humus, mussel shell layer	Charcoal, fine shell	1575 $\pm$ 65	Sample possibly crosscuts two strata.
SI-1570	1973	SE10L, level 10, 116-118"	Clam shell layer	Charcoal, fine shell	1705 $\pm$ 65	
SI-776	1972	SE5G, level 8, 35" E, 25"	Circular fire hearth	Charcoal	1395 $\pm$ 90	Corrected for isotopic fractionation
SI-777	1972	SE5H, 108-110", SW 1/4		Charcoal	1300 $\pm$ 80	Corrected for isotopic fractionation
SI-4964	1981	SW20G, level 3, 24-26"	Shell midden mixed with dietary bone and stratified with humus	Charcoal	1000 $\pm$ 65	Lab data sheet also reports a second date for this sample of 1285 $\pm$ 70; sample cross-cut two strata
SI-4965	1981	SW20G, level 3, 28-30"	Shell midden mixed with dietary bone and stratified with humus	Charcoal	1170 $\pm$ 70	
SI-4966	1981	SW20G, level 4, 38-40"	Shell midden mixed with dietary bone and stratified with humus, ash, clam shell	Charcoal	1295 $\pm$ 70	Lab data sheet also reports a second date for this sample of

						1580 ± 70
SI-4967	1981	SW20G, level 4, 46-48"	Shell midden mixed with dietary bone and stratified with humus, ash, clam shell	Charcoal	1195 ± 80	Sample crosscuts three strata.
SI-4968	1981	SW20G, level 5, 58-60"	Shell midden mixed with dietary bone and stratified with humus	Charcoal	1655 ± 75	Sample crosscuts two strata.
SI-4969	1981	SW21G, level 6, 66-68"	Shell midden mixed with dietary bone and stratified with humus	Charcoal	1265 ± 70	
SI-4963	1981	SW19C-SW20C, level 4, mortuary features C, D, E	Mostly humus zone; minor amounts of clam shell, dietary bone and roots	Human rib	1755 ± 75	Corrected for isotopic fractionation
SI-653	1970	NE12F, level 5	Loose clam and mussel shell stratum	Charcoal	2055 ± 125	Date also reported as 2035 ± 125
SI-654	1970	NE12F, level 6/7	Humus and clam stratum	Charcoal	1245 ± 145	Date also reported as 1225 ± 145
SI-587	1969	NE12G, level 5, 53" b.s.	Associated with an 'antler' atlatl	Charcoal	1820 ± 90	
SI-655	1970	NE12G, level 9	Compacted clam shell and subsoil gravel below humus stratum	Charcoal	1380 ± 100	Date also reported as 1360 ± 100
SI-616	1969	NE14G, level 6, 60-62" b.s.		Charcoal	1450 ± 90	Depth is below datum, not below surface as reported.
SI-615	1969	NE14G, level 7, 80" b.s.		Charcoal	2110 ± 90	Depth is below datum, not below surface as reported.
SI-588	1969	NE14G, level 8, 87" b.s.		Charcoal	3140 ± 100	Depth is below datum, not below surface as reported
SI-656	1970	NE15F, level 7/8	Compacted clam shell	Charcoal	1905 ± 125	Date also reported as 1895 ± 125
SI-657	1970	NE17F, level 8	Compacted clam shell, gravel, and humus	Charcoal	1485 ± 145	Date also reported as 1465 ± 145
SI-658	1970	NE18F, level 8	Compacted clam shell, humus and beach rock	Charcoal	1685 ± 105	Date also reported as 1665 ± 105

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